Relationship between legumes consumption and metabolic syndrome: Findings of the Isfahan Healthy Heart Program

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Original Article

Abstract

BACKGROUND: Epidemiologic studies have shown an inverse association between dietary fiber and metabolic syndrome (MetS). Therefore, the purpose of this study was to investigate the association between MetS and consumption of legumes in adults in Isfahan, Iran.

METHODS: This cross-sectional study was carried out on 2027 individuals who were a subsample of the 3rd phase of the Isfahan Healthy Heart Program (IHHP). Basic characteristics information such as age, sex, smoking status, and physical activity were collected using a questionnaire. A validated 48-item food frequency questionnaire was used to assess dietary behaviors. Blood pressure, waist circumference (WC), glucose, triacylglycerols, and high-density lipoprotein cholesterol were measured, and MetS was defined based on Adult Treatment Panel III guidelines. Multiple logistic regression models examined associations of frequency consumption of legumes with MetS occurrence and its components.

RESULTS: All MetS components were less prevalent among subjects with regular legume intake (P < 0.01). Legume intake was inversely associated with the risk of MetS, after adjustment for confounding factors in women. Life style adjusted odds ratio of Mets between highest and lowest tertile and no consumption (as reference category) of legume intake were 0.31 (0.13, 0.70), 0.38 (0.17, 0.87), respectively, in women (P = 0.01).

CONCLUSION: This study showed that age has a crucial role in MetS incidence; therefore, after further age adjustment to lifestyle adjusted model there was no significant difference in lower and higher tertile of legume intake and MetS.

Keywords: Legumes, Metabolic Syndrome, Iran

Introduction

The metabolic syndrome (MetS) may contribute to the increase in the risk of cardiovascular disease (CVD) and diabetes.[1] This condition affects at least one quarter of the population in developed countries, and its prevalence has steadily increased in recent years.[2] The prevalence of MetS, based on Adult Treatment Panel (ATP) III criteria, is more than 25% in developed countries.[3] However, it seems this figure is relatively higher in developing countries; for example, the prevalence of this syndrome has been reported to be 21.0% in Oman, 39.6% in Emirate, 22.5% in Iran, and 33.4% in Turkey.[4-6]

Many studies have revealed a clear relationship between diet and components of MetS.[7,8] Having a healthy food pattern, which includes cereals, fish, legumes, vegetables, and fruits, is inversely associated with waist circumference (WC), blood pressure (PB), triglycerides (TG), and positively

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linked with high density lipoprotein-cholesterol (HDL-C) levels, which are all well-known components of the MetS.[9] Epidemiologic studies have shown an inverse association between dietary fiber and MetS.[10-12] In this regard, Bazzano et al. reported a significant inverse relationship between legume intake and risk of CVD.[13] They reported that legume consumption of 4 times or more per week, compared with less than once a week, was associated with a 22% lower risk of coronary heart disease (CHD) and an 11% lower risk of CVD.[13] Additionally, the current findings indicate that a dietary pattern characterized by high consumption of fruit, vegetables, poultry, and legumes is associated with reduced risk of insulin resistance and the MetS in Iranian females.[14] Although many studies have been done to find the role of nutritional groups, especially fiber source foods, with Mets, to our knowledge, this study is the first to provide evidence related to the role of legumes according to sex and lifestyle factors.[15,16] Therefore, the purpose of this study was to investigate the association between MetS and consumption of legumes in adults in Isfahan, Iran.

Materials and Methods

This is a cross-sectional study based on data from the 3rd phase of the Isfahan Healthy Heart Program (IHHP) in 2007. Using a stralificated cluster random sampling, 2027 individuals were selected from Isfahan and Najafabad counties, according to age, sex, and rural and urban population distribution. In this survey, multistage, cluster random sampling design was used. The methodology has been previously published in detail elsewhere.[17,18] The samples were 19 years old, had no hemorrhagic diseases and mental retardation, had Iranian nationality, and were living at their current address for at least 6 months. Pregnant and breast-feeding women were excluded from the study.

To determine validity and reliability of the questionnaire 2 pilot studies have been performed on 200 adults who were not part of the final sample. Questioners were completed 2 times in 2 weeks.

The questionnaire's reproducibility was examined by pretest and posttest on 200 subjects. The final questionnaire was approved by the Medical Education Development Center, and Cronbach's alpha correlation coefficient was determined (Cronbach's alpha = 0.80).[19]

Demographic data, such as age and sex, nutritional knowledge, attitude and practice, and medical history, were obtained. Moreover, clinical and paraclinical examinations were conducted.

Trained interviewers collected demographic information and information about the individuals and their nutritional practices.

We used updated ATP III definition for MetS. In this definition participants should meet at least 3 of the following criteria: WC $\geq$ 102 cm in men and $\geq$ 88 cm in women; HDL-C < 40 mg/dl in men and < 50 mg/dl in women or specific treatment for this lipid abnormality; TG $\geq$ 150 mg/dl or specific treatment for this lipid abnormality; systolic BP (SBP) $\geq$ 130 mmHg or diastolic BP (DBP) $\geq$ 85 mmHg or treatment of previously diagnosed hypertension; and fasting blood glucose (FBS) $\geq$ 110 mg/dl or using drug.[20] Serum total cholesterol (TC) and TG were measured with enzymatic colorimetric methods (Elan Auto Analyzer 2000). HDL_C was measured after the precipitation of other lipoproteins (with a heparin manganese chloride mixture) and low density lipoprotein-cholesterol (LDL) level was derived from the Friedewald et al. equation.[21] Serum glucose concentration was measured using an enzymatic reaction.[22] The variation coefficient was < 5% for all laboratory measurements.

All of the tests were performed at the Isfahan Cardiovascular Research Center laboratory which is under the qualitative control of the National Reference Laboratory [a WHO (World Health Organization) collaborating center]. BP was measured using a standard mercury sphygmomanometer on the right arm with subjects seated and after at least 10 minutes resting. WC was measured in the middle distance between the lowest rib and the highest end of the pelvis.[23]

Assessment of dietary intake

Dietary behaviors were assessed with validated qualitative 48-item food frequency questionnaire (FFQ).[19] As the present study is an interventional program similar to the countrywide integrated noncommunicable diseases intervention (CINDI) program, the FFQ was adapted from the CINDI program questionnaire.[24] For each food item, participants were asked to report frequency consumption during the previous year. Dietary intake on the FFQ questionnaire was first classified into 12 food groups as follows: (i) fruits; (ii) vegetables; (iii) dairy products; (iv) non-hydrogenated vegetable oils; (v) legumes; (vi) nuts; (vii) white meat; (viii) grains; (ix) hydrogenated vegetable oils; (x) red meat; (xi) processed meat; and (xii) sweets and pizza. We then quantified participants' intake from these groups and divided the participants into quintiles according to their intake. Individuals in the 2 highest intake quintiles

for fruits, vegetables, dairy products, non-hydrogenated vegetable oils, legumes, nuts, and white meat were classified as having a healthy diet and were given a score of 1 for each food group. However, those in the lowest, second, and third intake quintiles of these food groups were given a score of 0. For unhealthy food groups, like grains, hydrogenated vegetable oils, red meat and processed meat, and sweets and pizza, the opposite was done; individuals in the lowest and second quintiles were given a score of 1 and those in the three highest quintiles were given a score of 0. All grains were classified as unhealthy, because the ones ordinarily consumed in Iran are refined rather than whole. Pizza plus sweets were counted as a single unhealthy food group, because both are commonly consumed in Iran and contain harmful fats, such as trans-fats. It was not possible to separate low- and high-fat dairy products, because the distinction was not made in the consumption questionnaire; therefore, all dairy products were classified as a single, healthy food group. The total dietary score was calculated as the sum of the scores given for all 12 food groups. Thus, the total dietary score for each individual could vary from 0–12.[25] Data on physical activity and smoking behaviors were gathered by questionnaires. Physical activity, expressed as metabolic equivalent task (MET) minutes per week, were obtained through an oral questionnaire that included questions on 4 activity domains: job-related physical activity; transportation-related physical activity; housework and house maintenance activities; and recreation, sport, and leisure-time physical activity. We asked participants to think about all the vigorous and moderate activities they had performed in the last 7 days, considering the number of days a week and the time spent on these activities. Several questions on smoking behaviors were asked, with the following key questions used to categorize individuals: "Are you currently smoking (cigarettes, pipe, and hookah)?" and "What is the frequency of smoking in a day, week, or month?".[25] Quality of life was assessed using the world Health Organization Quality of Life Questionnaire BREF (WHOQOL-BREF). This is 26-item questionnaire that assesses life in the physical, psychological, social, and environmental domains.[26]

Statistical analysis

Data were analyzed by SPSS (version 15; SPSS Inc., Chicago, IL, USA). The results were presented as absolute frequencies and percentages for categorical variables and mean ± SD for continuous variables. Categorical variables were compared using chi-square test or Fisher's exact test when more than 20% of cells with the expected count of less than 5 were observed. Continuous variables were also compared using Student's independent t-test. Logistic regression was performed between participants without any MetS components, and MetS subjects as dependent variable and tertiles of legume as independent variables in 4 models based on sex. The crude model was unadjusted. The first model was adjusted by dietary score, second model was adjusted by lifestyle status (physical activity, dietary score, quality of life, and smoking status), the third model was adjusted by age and lifestyle status, and the forth was adjusted by body mass index (BMI), age, and lifestyle behavior. To solve the co-linearity problem between dietary score and legume intake in all models, we used residual of linear regression as dietary score adjusted legume intake, with dietary score as dependent variable and legume intake as independent variable. To determine P-value for trend across tertile of legume, we assigned the median consumption of legume to individual's variable as continuous variable in logistic regression for participants without any MetS components vs. MetS subjects. P-values < 0.05 were considered as statistically significant.

Results

In this study 982 (617 women and 365 men) subjects with MetS and 1045 (396 women and 649 men) without any MetS components were enrolled with an average of 40.58 ± 16.18 years. Demographic characteristics, such as age, sex, and obesity indices, and life style behavior variables, such as physical activity, dietary score, quality of life, and smoking status, are presented in table 1. Significant differences in all study parameters have been found between the groups (P < 0.001). The frequency of daily intakes of legumes in subjects with MetS was 2.41 ± 1.92 and in the group without any MetS components was 2.61 ± 1.92 (P < 0.001).

Frequency of MetS components based on legume consumption was shown in table 2. All MetS components are more prevalent among subjects without regular legume intake (P < 0.001). In other words, these results showed that higher consumption of legumes is related with lower prevalence in all components of MetS (P = 0.01).

Multiple logistic regressions were done to find adjusted odds ratio for having MetS across tertile of legume consumption as shown in table 3. We found a significant inverse relationship between legume intake and risk of MetS among females. Life style adjusted odds ratio of MetS between highest and lowest tertile vs. no (as reference category) legume intake were 0.31 (0.13, 0.70) and 0.38 (0.17, 0.87), respectively, in females (P-value for trend = 0.01).

Table 1. Characteristic of participants of the Isfahan Healthy Heart Program

	Number of components of metabolic syndrome		
	0 components[*]	≥ 3 components[**]	P
Number	1045	982	
Sex (female)[§]	396 (37.9)	617 (62.8)	< 0.001
Smoker[§]	240 (23.0)	124 (12.6)	< 0.001
BMI category[§]			
25 < BMI < 30	231 (23.6)	427 (44.1)	< 0.001
BMI ≥ 30	18 (1.8)	415 (42.8)	
Age category[§]			
< 40 (year)	843 (80.7)	286 (29.1)	
41-60 (year)	161 (15.4)	436 (44.4)	< 0.001
> 60 (year)	40 (3.8)	260 (26.5)	
Healthy dietary score[*]	150 (14.4)	188 (19.1)	0.004
Age (year)[£]	32.09 ± 12.03	49.59 ± 15.11	< 0.001
BMI[£]	22.77 ± 3.43	29.55 ± 4.33	< 0.001
Leisure time physical activity (minutes per week)[£]	200.47 ± 262.61	120.82 ± 194.14	< 0.001
Dietary Score[§]	5.38 ± 1.96	5.69 ± 1.98	< 0.001
Quality of life[£]	68.25 ± 12.24	63.71 ± 13.41	< 0.001

BMI: Body mass index

[*] Subjects without any MetS components; [**] MetS subjects; [§] Indicates: P-value obtained from chi-square test; [£] Indicates: P-value obtained from Student's t-test

Table 2. Frequency of metabolic syndrome components based on legumes consumption

Variables	Tertile of legume				P
	No consumption	Tertile 1 (< 2 times per week)	Tertile 2 (2-3 times per week)	Tertile 3 (≥3 times per week)	
High BP[*]	27 (43.5)	205 (38.2)	190 (31.0)	237 (31.3)	0.010
high FBS[**]	16 (24.6)	95 (17.1)	79 (12.7)	93 (11.9)	0.003
Low HDL[$]	41 (64.1)	246 (44.5)	247 (39.7)	317 (40.7)	0.001
High TG[£]	41 (64.1)	232 (41.8)	225 (36.1)	293 (37.6)	< 0.001
High WC[§]	37 (60.7)	240 (45.0)	209 (34.7)	279 (37.2)	< 0.001

[*] Blood presser ≥ 130/85 mmHg or treatment; [**] Serum glucose ≥ 110 or treatment; [$] Low high-density lipoprotein cholesterol < 40 mg/dl in makeanol < 50 in female or treatment; [£] Serum triglyceride ≥ 150 mg/dl or treatment; [§] Waist circumference > 102 cm in males and > 88 in females
BP: Blood pressure; FBS: Fasting blood glucose; HDL: High density lipoprotein; TG: Triglycerides; WC: Waist circumference

Table 3. Adjusted odds ratio and 95% confidence interval for metabolic syndrome (≥ 3 components) vs. normal (0 components) across tertile of legume consumption of the Isfahan Healthy Heart Program

Models	Tertile of legume				P for trend
	No consumption	Tertile 1 (< 2 times per week)	Tertile 2 (2-3 times per week)	Tertile 3 (≥3 times per week)	
Crude					
Female	Ref	0.39 (0.17, 0.86)	0.31 (0.14, 0.68)	0.29 (0.13, 0.65)	0.005
Male	Ref	0.68 (0.27, 1.70)	0.45 (0.18, 1.13)	056 (0.23, 1.38)	0.180
Model 1[*]					
Female	Ref	0.39 (0.18-0.87)	0.31 (0.14, 0.70)	0.29 (0.13, 0.66)	0.004
Male	Ref	0.72 (0.29-1.81)	0.49 (0.19-1.25)	0.56 (0.23-1.38)	0.080
Model 2[**]					
Female	Ref	0.38 (0.17, 0.87)	0.31 (0.13, 0.71)	0.31 (0.13, 0.70)	0.017
Male	Ref	0.66 (0.25, 1.71)	0.47 (0.18, 1.21)	0.50 (0.19, 1.28)	0.060
Model 3[***]					
Female	Ref	045 (0.17, 1.19)	0.44 (0.17, 1.14)	055 (0.21, 1.41)	0.800
Male	Ref	0.73 (0.24, 2.26)	0.57 (0.19, 1.77)	0.68 (0.22, 2.07)	0.620
Model 4[£]					
Female	Ref	0.22 (0.05-0.93)	0.17 (0.04, 0.74)	0.21 (0.05, 0.89)	0.290
Male	Ref	0.43 (0.09, 2.07)	0.37 (0.08, 1.80)	0.41 (0.09, 1.97)	0.660

Ref: Reference category; [*] adjusted by dietary score; [**] adjusted by life style (Physical activity, quality of life, dietary score, and smoking status); [***] adjusted by life style and age; [£] adjusted by life style, age, and body mass index (BMI)

Discussion

Our results showed an adverse relationship between legume consumption and MetS by potential confounder adjustment. Similar to our findings, another national study showed that increase in legume intake, from the first quartile to the latest quartile, causes significant changes in some components of MetS.[27] Our findings revealed that components of MetS improved by higher legume consumption in subjects with MetS. Moreover, 2 studies performed on diabetic patients revealed that higher consumption of legumes improved glycemic control and insulin resistance.[28,29]

International diabetes mellitus guidelines recommended the consumption of legumes (including beans, and chickpeas) and controlling of the glycemic index.[30] Results of an Italian National Research revealed that daily consumption of legumes decreases systolic blood pressure.[31] Alizadeh et al. demonstrated that the consumption of a legume-rich hypocaloric diet for 6 weeks reduced some anthropometric measures, such as waist and hip, among healthy premenopausal women with central obesity.[32] Our findings demonstrated that an increment in intake of legume from the lowest tertile to the highest decreased WC.

Several cross-sectional and prospective studies have also indicated the negative association between legume and fruit consumption and obesity and cardiovascular dieses.[33] In the present study, we found an adverse relationship between MetS and legume consumption in women after adjusting for confounding factors such as life style (physical activity, dietary score, quality of life, and smoking status). To date, few observational studies have examined the association of legume intake with MetS.[16] Lignin, as a major dietary insoluble fiber source, may control homeostasis of glucose and insulin sensivity as well as weight reduction; therefore, they might play a crucial role in controlling MetS.[34] Azizi et al. showed that intake of soluble fiber was associated with reduced risk of MetS. They showed that 5 g increment in intake of soluble fiber was associated with a reduction of 54% in risk of MetS.[35]

Several population studies have reported an increase in the prevalence of the MetS with age, regardless of definition, although some have reported a peak in the 7th decade and then a decline in both sexes.[36,37]

This was evident especially in women, with a sevenfold increase in prevalence from the 20-29 year olds age group to the 80-89 year olds age group.[38] This study showed that age has a significant relationship with prevalence of MetS; therefore, after age adjustment, there is no significant difference in lower and higher tertile of legume intakes. Findings from the third National Health and Nutrition Examination Survey show the percentage of people with MetS differs by age group. It is currently estimated that 13% of adolescents in the United States have metabolic syndrome. Approximately 24% of young to middle-aged adults and 40% of adults aged 70 years or older have MetS.[39,40] Another study evaluated the association between total dietary fiber and its types and sources with the risk of MetS. Among sources of dietary fiber, fruit fiber and legume fiber were significantly and inversely associated with the risk of having MetS. After further adjustment for age, gender, lifestyle, and dietary confounders, a substantial reduction in the risk of MetS was observed with increasing fruit fiber and legume fiber intake.[41] The strengths of this study are its large sample size consisting of participants with various socioeconomic and demographic characteristics, random sampling from two counties in central Iran, and control over a wide variety of potential confounders.

Limitation

These findings are limited due to the use of a cross-sectional design; therefore, we could not assess cause and effect relationship between MetS and legume. However, the evaluation of dietary intake of participants has a strong relationship with previous dietary intake. In addition, after adjustment for potential lifestyle confounders, unknown conditions may confound the relation between legume intake and MetS.

Conflict of Interests

Authors have no conflict of interests.

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